Homework XI

Session XI.2

1. Recall that the energy of a particle in a one dimensional box is

$$E_n = \frac{n^2 h^2}{8mL^2} \,.$$

What would be a general expression for the energy of emitted photons in transitions that change n by 2, this is, from n to n-2? Write the energy of the photon in terms of the initial particle energy level's quantum number n.

2. An electron in a benzene molecule makes a reasonable approximation to an electron confined to a hoop. If the radius of the benzene molecule is about 5×10^{-10} m, and the electron has the lowest allowed angular momentum of $h/2\pi$, what is the velocity of the electron? (You may wish to recall the electron mass is 9×10^{-31} kg, and angular momentum is $L = rp = rmv$.)

Session XII.1

3. The graph below shows a two dimensional particle in a box wave function. (See colors online) What are the quantum numbers associated with this wave function? Explain how you got your answer.
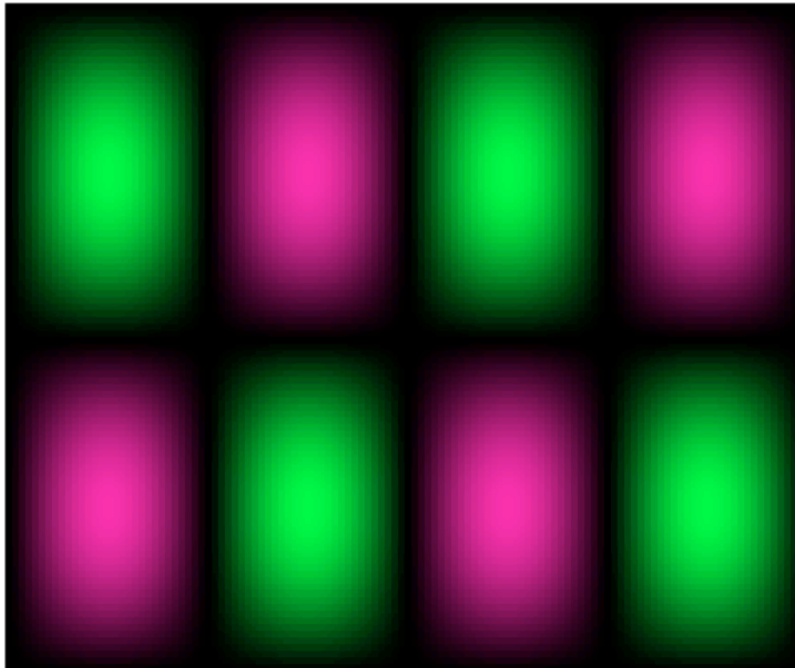
4. Sometimes two different wave functions will have the same energy. This circumstance is called a degeneracy, and the two wave functions are termed degenerate.

a. Show for a square box that (2,3) and (3.2) are degenerate (this sort of degeneracy is called a symmetry degeneracy).

b. Show for a square box that (5,5) and (7,1) are degenerate (this sort of degeneracy is called an accidental degeneracy).

5. What is the ground state energy of an electron confined to a 3 dimensional cubic box 2×10^{-10} m on a side? This should be a rough (within a factor of 5 or so) estimate of the kinetic energy of a hydrogen atom; how does it compare to the actual value of about 1 x 10^{-18} J?